CONFIDENTIAL

M.R.P. 1030
S.C.II/228
18th January, 1957

AIR MINISTRY

METEOROLOGICAL RESEARCH COMMITTEE

Draft Report of Chairman of the Synoptic and Dynamical Sub-Committee to the Meteorological Research Committee for the year ending 31st March, 1957

1. Constitution. The Sub-Committee was constituted by the Meteorological Research Committee in March, 1948. The membership at the end of the year under review was:-

Professor P.A. Sheppard (Chairman)	- Imperial College, London
Professor H. Bondi	- King's College, London
Instructor Commander K.A. Bowell	- Naval Weather Service
Mr. C.J. Boyden	- A.D.M.O.(C.F.)
Dr. E.T. Eady	- Imperial College, London
Dr. A.G. Forsdyke	- A.D.M.O.(C.R.)
Mr. E. Gold	- -
Professor M.J. Lighthill	- Manchester University
Mr. P.J. Meade	- A.D.M.O.(S.I.)
Mr. S.P. Peters	- D.D.M.O.(F)
Mr. J.S. Sawyer	- A.D.M.O.(F.R.)
Dr. J.M. Stagg	- P/D.D.M.O.
Dr. R.C. Sutcliffe	- D.D.M.O.(R)
Mr. R.G. Veryard	- A.D.M.O.(C.S.)

Dr. A.W. Brewer and Sir Charles Normand of the main Committee were members of the Sub-Committee until November, 1956 when the Committee decided that its members should not be appointed to the Sub-Committees, except as Chairmen, but would continue to attend meetings of the Sub-Committees as appropriate.

2. Meetings and papers. The Sub-Committee held four meetings at which 19 papers and reports were considered (see Appendix).

3. Present position regarding the more important items. The following notes refer to some of the more important items of the Programme of Investigations 1956/57 (M.R.P.967A).

(a) Development of a system for checking the accuracy of forecasts - II.1(a). A critical review of the extensive literature of forecast verification has been carried out and practical tests of the more promising indexes of success are in progress in order to provide a basis for recommendations on verification procedure.

(b) The forecasting of rainfall - II.3(d). A detailed study of the vertical motion and rainfall associated with two warm fronts is nearing completion. The fronts were selected because the synoptic charts in respect of the two fronts were similar, but the rainfall amounts differed considerably. Calculations by current techniques of numerical forecasting failed to show a significant difference between the two cases. However the vertical component of air motion was undoubtedly greater in one case than the other, but the difference appears to be associated with a smaller scale of horizontal motion than that dealt with by numerical forecasting techniques and may be connected with the humidity distribution.

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(c) Formation and dispersal of stratocumulus cloud - II.3(h). Observations obtained by the Meteorological Research Flight in the vicinity of stratocumulus have been analysed. The most striking feature of the observations is the very sharp inversion and hydrolapse above the cloud and the presence of appreciable bumpiness in this layer. An attempt is being made to draw up a heat and water-vapour budget for typical stratocumulus cloud. There are numerous difficulties, but it is difficult to see how a steady state can be maintained except in a region where the air is slowly subsiding.

(d) Orographic influences on air-flow - II.4(d). Evidence of the vertical air motion in standing waves has been obtained from the rate of ascent of radio-sonde balloons. An estimate of the wavelength and the vertical variation of amplitude has also been obtained. It has been found possible to make a theoretical calculation of these quantities from the temperature and wind profile in the air-stream and good agreement has been achieved with the values from the radio-sonde data.

Reports of standing waves have been collected from civil air-crews over a two-month period. These are being analysed.

Some numerical solutions of the perturbation equations for air-flow over a two-dimensional ridge have been carried out and give some additional insight into the character of the flow. The proper treatment of the upper boundary condition in such calculations has been studied, and difficulties now appear to have been resolved. It appears likely that lee-waves can occur in suitable cases as a result of the difference in static stability between a slightly stable troposphere and a highly stable stratosphere, as well as a result of the opposite distribution of stability with the more stable layer near the ground.

(e) Investigations relating primarily to long-range forecasting. - II.5. The regular preparation of charts of the "anomalies" of 5-day mean temperature over a large part of the Northern Hemisphere has been continued on a current basis. The characteristics of these charts have been discussed in a report to the Committee (M.R.P.994). Similar charts for monthly periods have been used to select previous years with a similar anomaly pattern to that of the current year, and experimental forecasts have been prepared on the basis that the following month should be similar in the current and in the "analogue" year or years. The success of the technique is being critically examined, but preliminary indications suggest that it is somewhat better than chance.

Some effort has been devoted to the study of the statistical properties of time series. In particular a report has been prepared on the serial correlations in daily temperature at Kew.

(f) Behaviour of depressions - II.7(a). An analysis has been made of the motion and deepening of depressions on the Atlantic which were associated with a wave-like distortion of the temperature field of moderate amplitude. The degree of consistency in the results is not sufficient to improve on present forecasting techniques.

(g) Methods of estimating and forecasting winds - II.7(f). An examination of the changes in the flow pattern at 100 mb has been carried out with a view to ascertaining whether the motion can be treated as non-divergent. Preliminary indications are that this is so.

The meteorological staff of Bomber Command have continued the routine preparation of 300 mb and 200 mb charts over Europe and Russia.

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Since July, 1956 the availability of data up to 200 mb over Russia has enabled tests to be made of a technique for relating the 300-200 mb thickness to the temperature at 200 mb.

Preparatory work is nearing completion for a new investigation into forecasting equivalent head-winds over a route by means of a regression equation which contains the latest wind observations from up to three stations.

(h) Fronts - II.8(a). Analysis continued of the results of flights conducted by the Meteorological Research Flight through fronts.

(i) Variations in space and time of the sea surface temperature in relation to the synoptic situation - II.9. Since consideration of M.R.P.949 by the Sub-Committee some further attention has been given to the energy exchange between the atmosphere and the ocean.

(j) Application of numerical methods to forecasting - II.10(a) and (c). Consideration has been given to possible improvements in the basis of methods of numerical weather prediction, and the equations have been formulated which would permit (a) some of the effects of the presence of the stratosphere to be included and (b) allowance to be made for the non-geostrophic component of the motion. Programmes have been written to permit the calculations including stratospheric effects to be carried out on the electronic computer at Manchester University but some computational difficulties remain to be overcome.

The computational errors arising in the present finite difference methods of calculation have been studied and show that the computational error may amount to 30 per cent of the computed change in 500 mb height. This requires further investigation.

An alternative integration procedure based on a representation of the hemispherical flow at 500 mb in terms of spherical harmonics is being studied, but difficulty is being experienced in obtaining adequate accuracy in the representation.

Methods of "objective analysis" have been developed. These enable the initial data for a numerical forecast to be obtained from the radiosonde and wind observations together with a preliminary estimate of the pressure field based on earlier data. (The main aim is to avoid the need to plot observed data on a map, draw isopleths and finally interpolate by eye - a time-consuming procedure.) The computed charts based on objectively analysed data do not appear to differ materially from those based on data obtained from a conventional analysis.

Considerable effort has been devoted to the training of staff and the rewriting of computational programmes so that the Mercury computer, on order for the Meteorological Office, can be used for research on the forecasting problems as soon as it becomes available, probably in mid-1957.

World Climatology

(k) World climatology of the upper air (temperature and wind) - II.12(a), (b), (c). Seasonal charts of the average height of the standard isobaric surfaces over the world are being revised. Charts of the north polar region to 55°N. are now available for January, April, July and October and charts for the rest of the world to 55°S. have been completed for January.

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The problem of charting the variation of wind about its vector average is being studied.

(l) Distribution, inter-relation and persistence of anomalies of pressure temperature and rainfall in different parts of the world; study of CLIMAT and CLIMAT TEMP. data - II.12(d). Basic work is well advanced on plotting and drawing monthly mean M.S.L. pressure maps for homogeneous periods of years for both the northern (1900-1939) and southern hemispheres (1949-1953). Such homogeneous charts have not been available before; they are needed before anomaly patterns can be properly derived. World charts of the standard deviation of monthly mean M.S.L. pressure have also been drawn based on data published in South Africa.

A programme has been instituted under which monthly CLIMAT data are plotted as received for the whole world. Each month a discussion is held covering the mean and anomaly patterns revealed on these maps, and sequences of these discernible from successive maps.

(m) General circulation of the atmosphere - II.12(e). Extraction of daily values of pressure, temperature and rainfall for a standard period of years for various key stations in the northern hemisphere has been carried out with a view to identifying recurrent synoptic circulation patterns associated with particular times of the year. The Lamb-Levick type classification of weather patterns for the general region of the British Isles is being kept up to date with the same object in view.

Some exploratory work has been done in the preparation of current monthly charts showing the number of days with cyclonic and anticyclonic circulation types for a grid of "squares" covering North America, the Atlantic and Europe.

(n) Climatic changes and trends - II.12(g). A draft report has been prepared on the geographical distribution of frequency of depressions in January of each decade since 1880 in part of the northern hemisphere between 100°W. and 60°E. This work suggests that the present period has some similarities with the 1890's characterised by cold winters in the British Isles. In this connexion some studies have also been made of the extent of ice in the Arctic seas.

A paper on recent seasonal trends in the number of rain days and mean rainfall per rain day over Great Britain has been prepared for the Meteorological Magazine.

(o) World distribution of water vapour - II.12(h). Preparation is in hand of world charts of average amounts of total precipitable water in the upper air in each of the four seasons.

A climatological study has been made of the water vapour content of the upper troposphere and lower stratosphere over southern England based on the observations of the Meteorological Research Flight.

World maps of the mean daily vapour pressure for January, April, July and October have been completed and, with accompanying text, are in course of preparation as a Geophysical Memoir.

(p) Tropical meteorology. Arrangements were made with the Colonial Office for A.D.M.O.(C.R.) to undertake a survey of research requirements in tropical meteorology. This has been begun by correspondence with the Directors of Colonial Meteorological Services and by a visit to Nigeria and the Gold Coast. Other visits are planned.

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Regional and synoptic climatology

(q) Areas associated with rainfalls of various intensities and durations - II.13(b). To obtain more detailed information on the intensity-duration frequency distribution of heavy falls of rain it is planned (in conjunction with other authorities) to set up a network of about 250 open-scale rainfall recorders in Great Britain: about 25 of these have been installed at official stations. Methods of analysis have been established.

(r) Variations of intense falls of rain over small areas of the British Isles - II.13(f). Sixteen open-scale rainfall recorders have now been installed on a small area at Cardington to provide data for this investigation, with special reference to thunderstorm rainfall.

(s) Frequencies, for selected stations in Great Britain and overseas, of associated dry and wet bulb temperatures, based on hourly values - II.13(c). Progress continues in the extraction and summarizing of the observations.

(t) Occurrence, base, height, intensity and thickness of temperature inversions and the associated humidity lapse rate at all levels up to the tropopause in relation to the synoptic situation, particularly in maritime regions - II.13(d). An analysis of temperature inversions over the United Kingdom has been completed, but relationships with the synoptic situation have not yet been examined.

Applied climatology

(u) Agriculture and horticulture - II.14(a)

(i) Statistical investigations. To obtain evidence of the size of 'least humid zones', humidity observations for 1942-46 at about 30 stations between Birmingham and Blackpool are being analysed with respect to wind direction and topographical position.

Analysis is in hand of earth temperatures at 1 ft. at some 100 stations for 1921-50, and of temperatures at five depths down to 4 ft. at a limited number of stations with different types of soil.

(ii) The liability to frost of particular localities. Further work on this problem is in progress at Rosemaund Experimental Husbandry Farm, and observations made in a large area near Hereford are being analysed. Mobile surveys by car have been made on selected radiation mornings in undulating country to the north of Harrow, and the results prepared for publication.

(v) The hydrological cycle with particular reference to available yield for water works and to drainage and flood problems for River Boards - II.14(b). In association with the Institution of Water Engineers and the Metropolitan Water Board, the Meteorological Office has cooperated in an evaporation investigation at the Kempton Park East Reservoir.

A report has been prepared on the rainfall over Dorset on 18th July, 1955 (floods at Weymouth and other places), with a comparison of the rainfall and flooding on that occasion with the last previous occasion of comparable rainfall (Exmoor, 1952).

C O N F I D E N T I A L

Appendix to M.R.P.1030 (Report of Chairman of S.C.II)

List of papers and reports considered by the Synoptic and Dynamical Sub-Committee in the year ending 31st March, 1957

M.R.P. No.	TITLE	AUTHOR
949	Some aspects of variations of air and sea surface temperature in short periods at ocean weather stations I and J of significance to the synoptic climatologist	R.F.M. Hay
965	Objective Analysis	D.H. Johnson
970	The harmonic representation of the annual temperature variation in different parts of the British Isles	J.M. Craddock
978	Long-period averages for the upper air	J.K. Bannon
981	Average height of the standard isobaric surfaces over the area from the North Pole to 55°N in July	H. Heastie
985	A preliminary study of atmospheric waves using radio-sonde data	G.A. Corby
986	The objective analysis of some 500 mb. charts	F.H. Bushby
987	Equivalent head-wind statistics for variable tracks	P. Graystone
994	A synoptic study of anomalies of surface air temperature over the Atlantic half of the Northern Hemisphere	J.H. Craddock and C.A.S. Lowndes
1002	An atmospheric model for numerical integration including the tropopause effects	E. Knighting
1003	A non-geostrophic extension of the Sawyer-Bushby model of the atmosphere suitable for numerical integration	E. Knighting
1005	Heat sources and sinks at the earth's surface	D.M. Houghton
1007	Twenty-fifth S.C.II Progress Report (March to August, 1956)	-
1015	The air flow over a ridge - the effects of the upper boundary and high-level conditions	G.A. Corby and J.S. Sawyer
1016	Numerical forecasts based on objectively analysed data	Vera M. Huckle
1020	Average height of the standard isobaric surfaces over the area from the North Pole to 55°N in April and October .	H. Heastie
1022	The movement of precipitation belts as observed by radar	W.G. Harper and J.G.D. Beimers
1027	Proposed amendments for 1957/58 to Part II of Research Programme for 1956/57 (M.R.P.967A)	-
1030	Draft report of Chairman of S.C.II to the M.R.C., year ending 31st March, 1957	-

C O N F I D E N T I A L

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